Mutation Detectives: Does the Environment Matter?

Imagine a trait that helps an organism in one habitat but creates a disadvantage after its environment changes. A mutation is a change in DNA that may affect an organism's traits. Fitness means reproductive success, or how successfully an organism passes its genes to future generations. Beneficial mutations increase fitness, harmful mutations decrease fitness, and neutral mutations do neither. Survival matters when it helps organisms reproduce successfully. A visible change can be neutral if it does not affect survival or reproduction.

Vocabulary Warm-Up: Use the Word Bank

Word Bank: neutral • environment • beneficial • fitness • harmful

1. An organism's reproductive success is its _____.
2. A mutation that increases reproductive success in a particular environment is _____.
3. A mutation that decreases reproductive success in a particular environment is _____.
4. A mutation that changes neither survival nor reproductive success is _____.
5. Conditions surrounding an organism make up its _____.

Investigate the eight fictional scenarios below. Compare organisms with each mutation to organisms without it in the same environment. Use only the stated evidence; do not assume that every changed trait affects fitness. Mutations do not appear because organisms need them. Environmental conditions influence whether an existing mutation provides an advantage.

Eight Mutation Scenarios: Classify

Directions: Read each scenario below and select beneficial, harmful, or neutral.

1. Dark beetles on dark soil: A mutation produces darker shells. Birds overlook dark beetles on dark soil. Compared with light beetles, more dark beetles survive and produce offspring.
    a. Beneficial
    b. Harmful
    c. Neutral
2. Dark beetles on pale sand: The same dark-shell mutation makes beetles easier for birds to spot on pale sand. Compared with light beetles, fewer dark beetles survive and produce offspring.
    a. Beneficial
    b. Harmful
    c. Neutral

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3. White pea flowers: A mutation changes purple flowers to white. In this self-pollinating population, both colors produce equally healthy plants and equal numbers of surviving offspring.
    a. Beneficial
    b. Harmful
    c. Neutral
4. Bacteria during antibiotic treatment: A mutation protects bacteria from an antibiotic, a medicine that targets bacteria. During treatment, protected bacteria survive and reproduce more successfully than bacteria without the mutation.
    a. Beneficial
    b. Harmful
    c. Neutral
5. Bacteria without antibiotics: The same protective mutation requires extra energy. Without antibiotics, these bacteria reproduce more slowly and leave fewer descendants than bacteria without the mutation.
    a. Beneficial
    b. Harmful
    c. Neutral
6. Fish with a DNA change: A mutation does not change a protein or any observable trait. In this lake, fish with and without the mutation survive equally well and produce equal numbers of offspring.
    a. Beneficial
    b. Harmful
    c. Neutral
7. Grasses during drought: A mutation produces deeper roots that reach underground water. During drought, these grasses survive better and produce more seeds that grow into new plants than shallow-rooted grasses.
    a. Beneficial
    b. Harmful
    c. Neutral

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8. Moths and flower nectar: A mutation shortens a moth's feeding tube. Where flowers have deep nectar, these moths obtain less food and produce fewer surviving offspring than moths with longer tubes.
    a. Beneficial
    b. Harmful
    c. Neutral

Directions: Choose the best answer for each question. Use the information from your reading in Canvas.

9. Why does the dark-shell mutation have different fitness effects on dark soil and on pale sand?

a. Its effect depends on the environment: camouflage on dark soil increases survival and reproduction, while being easier to spot on pale sand reduces them.
b. The mutation changes into a different DNA mutation when beetles move to pale sand.
c. Dark shells always increase fitness, but pale sand makes beetles reproduce less for unrelated reasons.
d. The mutation is neutral in both environments because the beetles have the same shell color.

10. Why are the pea-flower and fish mutations both neutral in their stated environments, even though only one causes a visible change?

a. Neither mutation changes survival or reproductive success; a visible trait change alone does not establish a fitness effect.
b. Both mutations are invisible, so neither can affect reproductive success.
c. The pea mutation is beneficial, but the fish mutation is harmful.
d. Both mutations are neutral because every mutation has no effect on fitness.

11. How could the frequency of the protective mutation change during continued antibiotic treatment and after treatment ends?

a. It could increase during treatment because carriers survive and reproduce more, then decrease after treatment ends if its energy cost lowers reproduction.
b. It must decrease during treatment because antibiotics cause bacteria to lose mutations, then increase after treatment ends.
c. It could increase during treatment and must remain equally common afterward, regardless of its energy cost.
d. It must become common before treatment begins because bacteria develop mutations in response to future needs.

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